Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	}	
	}	
Revision of Part 15 Rules of the Commission's	}	
Rules Regarding Ultra-Wideband	}	ET Docket No. 98-153
Transmission Systems	}	

<u>Reply Comments of Gary R. Olhoeft, Ph.D.</u>

Gary R. Olhoeft, Ph.D. submits these additional reply comments in response to the Notice of Proposed Rule Making (NPRM), FCC 00-163, and the request for comments on testing (performed by NTIA and others) in the proceeding referenced above. These comments specifically address the most recent submission provided to the FCC under this docket by Ben Sternberg, dated 17 May 2001.

Sternberg asks questions about the GPR-cell phone mutual interference tests published in Olhoeft (2000) that are answered in Appendix A to this reply comment. The original peer reviewed publication was page limited and was not allowed the space to publish all the details. In summary, the cell phone produced unacceptable interference to the ground penetrating radar system whenever it was on and in use or standby. The GPR could only be made to interfere with the cell phone by putting both systems in an unusual and contrived situation inside the basement of a large building where the cell phone connection to the nearest repeater tower was tenuous and placing the GPR antenna within a meter of the cellphone with aligned antenna E-field polarizations (an atypical position for the cell phone). Outside the building, the GPR could not be made to interfere with the cell phone under any circumstances of normal GPR use, even with the two right next to each other with maximum polarization coupling.

Sternberg also states "It is certainly reassuring that there have not been any reported cases of interference during operational GPR surveys. However, it is not clear that if someone had noted interference on their radio, whether they would have associated this interference with a crew that was performing a GPR survey in the vicinity." It is difficult to prove the absence of something. However, as noted in the May 7 reply comment of Olhoeft et al., the UK Radiocommunications Agency specifically looked for such evidence and found none. I have done numerous GPR surveys at civilian and military airports and at secure government agency facilities where prior to being allowed to perform the survey, I had to allow inspection of the equipment and to perform tests by turning the equipment on and off to see if it would trigger any kind of interference or trigger microwave motion or other security sensors and alarms. In no case did any of the GPR systems cause any interference or adverse response, and in all cases I was allowed to proceed with the surveys (most of which were performed for public health and safety reasons, like detecting unexploded ordnance, voids under pavements or runways, environmental contamination, or pre-excavation utility clearance). Some of the surveys failed because of large RF interference to the GPR, requiring scheduling of the GPR surveys when nothing could interfere with the GPR operation. In a few cases, we had to request that other RF sources be temporarily turned off.

In the original reply comment of 7 May 2001 to Sternberg's comment of 24 April 2001, a series of questions were asked about his test of interference from GPR transmissions on a nearby receiver. A number of those questions are still unanswered: With what kind of antenna was the AR8000 fitted? What was the type and where were the sources of voice transmissions? What was the geometry, and how were the voice transmitter, AR8000 receiver, and GSSI GPR 3200 antennas oriented with respect to each other, nearby objects, and the ground? Further, Sternberg states about the source of the voice transmissions "In addition, most stations were useable for only a short period of time, after which they apparently stopped transmitting. I then had to search for other stations that were affected by the interference." He further noted that "...only some radio stations were interfered with. Other radio stations ... did not receive any detectable interference ..." These suggest the source transmissions were highly variable as they were either intermittant at the source location or along the transmission path length (both of which are still unknown) as atmosphere/ionosphere conditions changed. This lack of source stability, complete lack of source description, along with the unfavorable soil conditions and GPR coupling do not suggest that this was remotely approaching a typical test of GPR use, let alone of probable interference by GPR to other systems. How can a test that cannot identify the source transmitter characteristics, transmitter location, path to the receiver, and other relevant transmission information be anything but an anecdotal, non-quantitative and poorly documented test that adds little to these proceedings?

Sternberg also states "Some of these papers show the accurate synthesis of a wideband response (including multiple resonance peaks) with just two frequencies and their derivatives." In support of this, he references several papers in the literature, including Miller (1998a). Miller states in his 1998a paper "Most EM phenomena, whether observed in the time domain (TD) or the frequency domain (FD), or as a function of angle or location, are not of interest at one or a few discrete times, frequencies, angles, or locations. Instead, they require essentially continuous representation over some specified observation interval." and "Resolving a response that contains many high-Q, closely spaced resonances requires slower sweeping rates or long observation times experimentally, or an excessive number of frequency samples or time steps computationally." Thin layers commonly produce this situation as shown in Frangos (2000) and Tsang et al. (1985). Miller then goes on to make the case that in certain circumstances and by making certain assumptions, simplification may be possible. However, I have to worry about the general case, because I don't know what I will encounter, and thin layers are only one example of such a problem. The thin layer problem alone occurs repeatedly in measuring snow and ice problems, pavement thickness, thin void detection, frozen ground, dry ground with recent rainfall, etc. It's a simple example of the more general case of constructive and destructive interference and complications from multipathing and multiple scattering, which can get really bad as the intrinsic material losses go down. In high loss systems that are very simple and well described by models, you can get away with only 3 to 5 frequencies per decade. In the general case, so few frequencies can get you into severe trouble very quickly above 1 MHz, and sometimes as low as tens of kilohertz. Hence the need in the general case for ultrawideband measurements with many frequencies.

Sternberg also states “When these techniques [for synthesizing broadband data from narrowband measurements] are applied to measured data, the key is to obtain sufficiently accurate data in order to be able to apply these mathematical techniques. Producing the accurate derivatives of the measurements is extremely challenging, but may be possible using new and innovative techniques.” In some areas, even current UWB GPR technology and sophisticated signal processing that used to work in the past are now beginning to fail because of rising RF noise levels. Sternberg then later states “I must stress, however, that considerable research is needed in order to make this technique viable for GPR soundings.” We have people who are using the existing proven technology now to solve serious public health and safety problems as noted in other comments by myself and others in these proceedings. We do not know of interference to other systems caused by such use. Shall we tell the next victims buried in an avalanche or blown up by an excavator hitting a plastic gas main: “Sorry, we used to be able to solve that problem, but we can no longer use that technology, and considerable research is needed before we can do it again.”

Respectfully submitted, 18 May 2001

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Frangos, W., 2000, High frequency impedance measurements for non-invasive permittivity determination, PhD thesis, Univ. Calif. Berkeley, 147p. (esp. Figures 6-5 and following)

Miller, E.K., “Model-Based Parameter Estimation in Electromagnetics: Part I. Background and Theoretical Development,” *IEEE Antennas and Propagation Magazine*, Vol. 40, No. 1, pp. 42-52, 1998a.

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Tsang, L., Kong, J.A. and Shin, R.T., 1985, Theory of microwave remote sensing: Wiley, NY, 613p. (esp. Figures 2.4, 2.5, 5.28, 5.29)

Appendix A - further description of the Olhoeft (2000) cell phone test

For these tests, a Motorola MicroT-A-C lite III model 34043WNHPA cellphone was used with its standard extensible whip antenna. The manufacturer's literature says it receives at 869.04-893.97 MHz and transmits with 0.6 watt nominal power at 824.01-848.97 MHz. The nearest cellphone repeater antennas were on the building across the street from the test site. The ground penetrating radar system was a GSSI SIR-8 with a Hewlett-Packard Omnibook 5000 CTS S-90 model 1200 using a ComputerBoards PCM-DAS16D/16 PCMCIA 16-bit A/D card connected by shielded cables, and using a GSSI 3102 nominal 500 MHz center frequency transducer. All equipment was in good condition as originally manufactured. The computer was turned on and off with no detectable response by the radar system. The GPR was turned on and off with no detectable response in the cell phone's acquisition of service or voice transmission outdoors, even with the cell phone placed on the ground right next to the operating 3102 transducer with the E-fields of the antennas like polarized for maximum coupling. The GPR system received noticable interference from the cell phone whenever it was in use within several meters of the GPR antenna.

To contrive a disadvantage for the cell phone, the entire setup was taken inside the nearby Green Center (one of the largest buildings on the Colorado School of Mines campus) and down below ground into the basement, behind 3 metal fire doors and a poured concrete and two concrete block walls. The signal strength bar indicator on the cell phone indicated 1/6 the signal strength compared to outside the building (and the cell phone does not work everywhere within this building basement). Inside of a 6 x 6 x 3 m high concrete black walled basement room where the cell phone did work, the tests were repeated. As noted and quantified in Figure 11 of Olhoeft (2000), the GPR with the cell phone off, in standby, and during active communication made a considerable difference to the GPR. (Note also in the same Olhoeft, 2000, paper the removal of RF noise by filtering GPR data taken on an active military range in Figures 2 and 3. However, there are limits to what signal processing can accomplish.) With the cell phone off, the radar could map the thickness of the concrete, see the rebar in the concrete, and see the sewer pipe beneath the floor. With the cell phone on and in standby, the sewer pipe could not be found. During an active voice conversation with the cell phone (anywhere in the room), the radar could marginally detect the rebar, and concrete thickness determination was not possible, nor was there any sign of the sewer pipe. With the radar operating and the antenna properly coupled to the linoleum tile covered concrete floor, the cell phone could not acquire service within about 1 m of the radar antenna when the antenna E-fields were like polarized (an unusual position for the cell phone), but having once acquired service outside that range, had no trouble keeping it right up to the cell phone touching the antenna, and with no noticeable change in the quality of the conversation up to contact.